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Construction of Slančíková Street - Wilson Riverside Bridge in Nitra

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Abstract

The new structure of a road cable-stayed bridge is introduced in the article. Some specialties, like a solution of sidewalks for cyclists and pedestrians by combination of steel and timber members, are presented. Anchorage of balancing hangers into an abutment by manner of prestressed rods represents another non-traditional solution. Pressured concreting of pylons and part of main girders was applied, too. The bridge was built to substitute an old cable-stayed footbridge, which was removed as soon as the new bridge structure had been completed. The new bridge was officially opened on June 11, 2011. Total weight of the steel structure represents 250 tons.

Keywords: steel-concrete composite structures; encased steel beams; railway bridges; parametric study.

1. Characteristics of the bridge

The bridge connects the banks of Nitra River between Slančíková Street and Wilson Riverside in the town Nitra. The bridge was designed as an integrated unit considering interaction between superstructure and substructure including foundation. From the static point of view, the superstructure represent two-span cable-stayed bridge with three parallel hangers in the longer span and two balancing hangers in the shorter span, see Fig. 1. Theoretic lengths of the spans are 41.53 m and 8.27 m. The total length of the bridge superstructure is 51.85 m. The free width, measured as a distance between the crash barriers, was proposed to 10.0 m. Total width of the bridge is 21.158 m. The bridge is on a forthright municipal road. In vertical direction, the structure is located at the highest point of a level arc. The composite steel and concrete bridge deck is designed in roof-shape cross slope along the whole length of the bridge. The pavements are placed on cantilever sidewalks. A combination of steel and black locust timber members were applied for the structure of sidewalks. In Fig. 2 and

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Fig. 3, the ground plan and the longitudinal section of the bridge, respectively, are presented. Fig. 4 shows the cross-section of the bridge above intermediate support, i.e. in the pylon position.

The substructure of the bridge is created by two end abutments No. 1 and No. 3 and an intermediate pier numbered as No. 2, see Fig. 2 and Fig. 3. A run-on slab with thickness 300 mm is fixed to the back of the abutments, too. The bridge foundation was designed by means of drilled piles. The manner of foundation and the length of piles were designed on the basis of previous geological prospecting.

The pot bearings were proposed to support the main girders of steel structure at the abutments and the intermediate pier. The bridge was designed according to the new European standards [1-4], which are in operation in Slovakia from April 1, 2010.

Fig. 1. The view of completed bridge

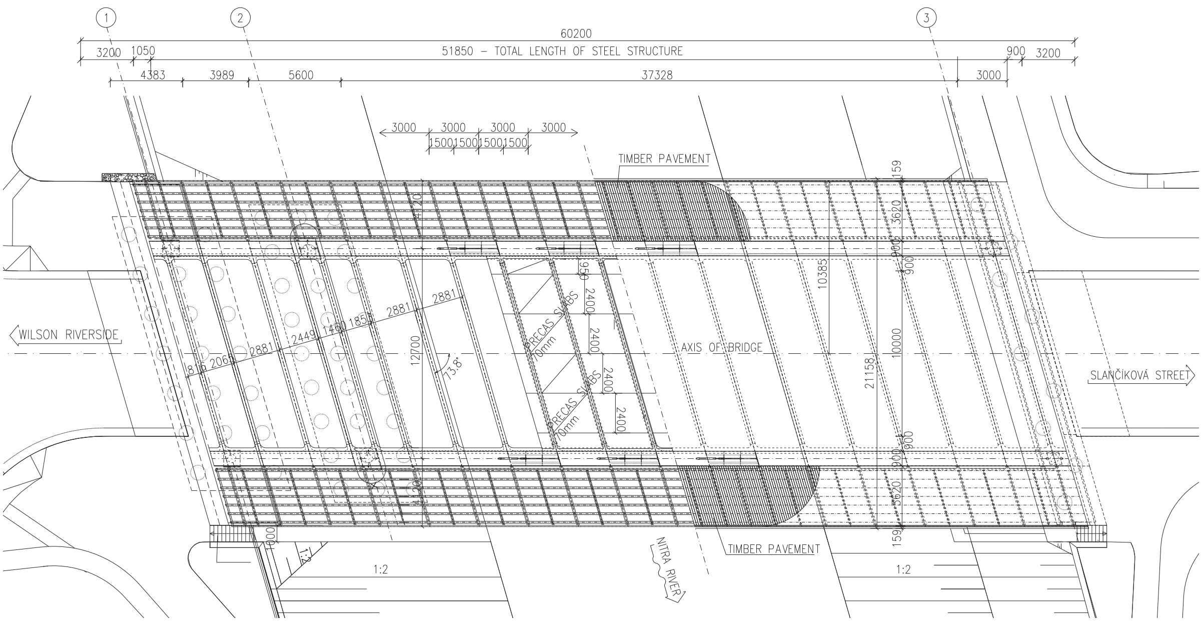

Fig. 2. Ground plan of the bridge

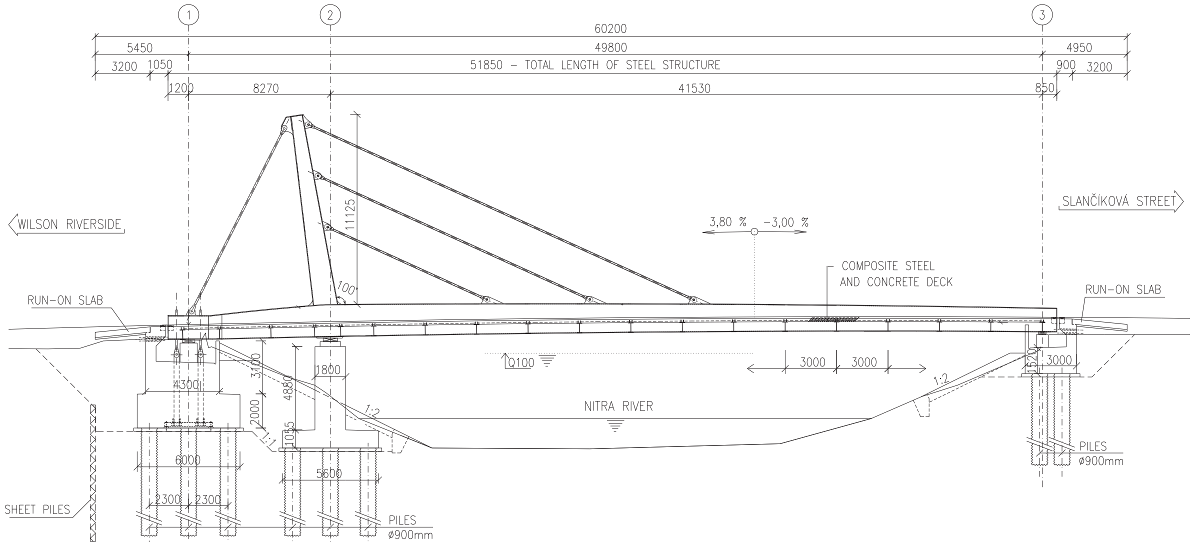

Fig. 3. Longitudinal section of the bridge

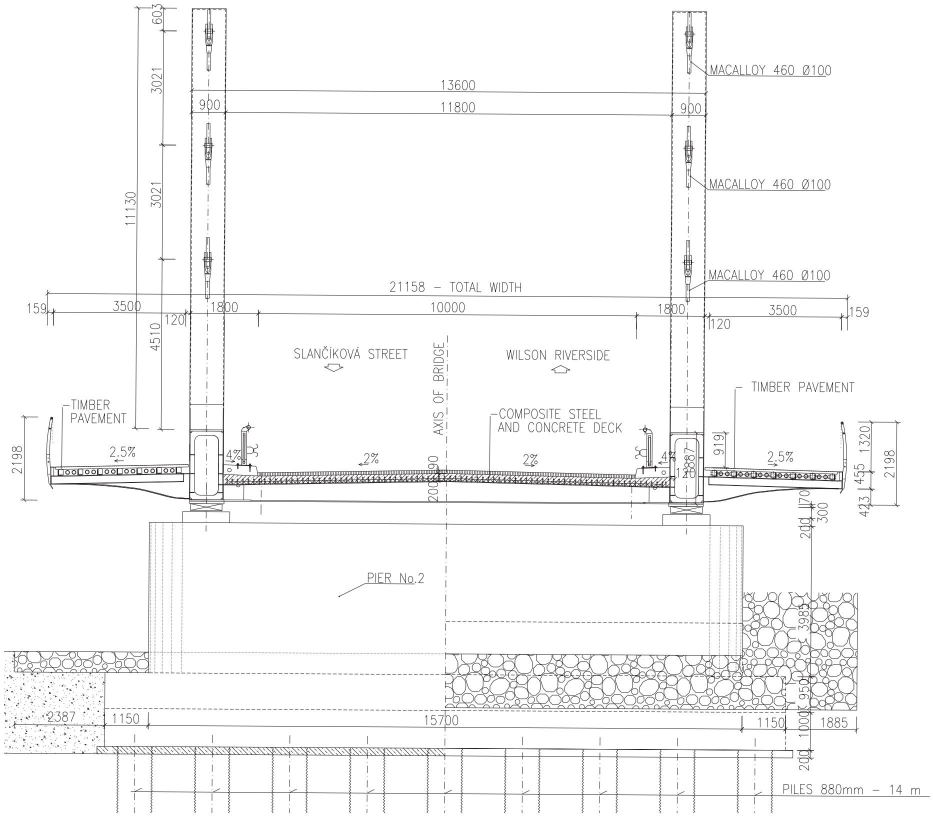

Fig. 4. Cross-section above the support No.2 (i.e. above the pier)

2. Main steel structure

2.1. Main girders

The load-bearing steel superstructure consists of two parallel box girders at axial distance 12.7 m. The height of main girder varies from the ends towards the pylon. The borders of this variation have a value 1400 mm above both abutments. The maximum height of girders reaches 1900 mm under the pylon. A linear change in the girder stiffness was considered in the static calculation. In fact, the bottom flange is designed parallel to the longitudinal shape of the bridge, while the top flange was formed into the shape of a general curve come from architect discussion. Thus, the height of girder cross-section is either equal or slightly higher than the cross section used in the static calculation through whole length. The top and bottom flanges have constant thickness 36 mm and the webs are constantly 16 mm thick. The box pylon, as well as crossbeams together with the sidewalk cantilevers, was considered to be fixed to the main girders. The diaphragms of main girder box section with hatch opening are 12 mm thick. They are welded in the points of crossbeams to ensure the requested box girder's shape. The thickness of the diaphragms in the points of hangers' anchoring is 25 mm. The same, 25 mm thick diaphragms were required also above the abutment No. 3, where the prestressed anchorage rods are installed, see Fig. 5. Because of problematic maintenance of inaccessible and unventilated places, the interior of cross-section of main girder in its shorter span and the interior of the pylon were filled with concrete using pressured concreting. The concrete class C20/25 was used. Then, the concrete filler was considered in estimation of load carrying capacity of the appropriate cross-sections. The concrete-filled parts of box cross-sections had to be equipped by longitudinal stiffeners to avoid buckling and out-of-plane deformation during the pressured concreting works.

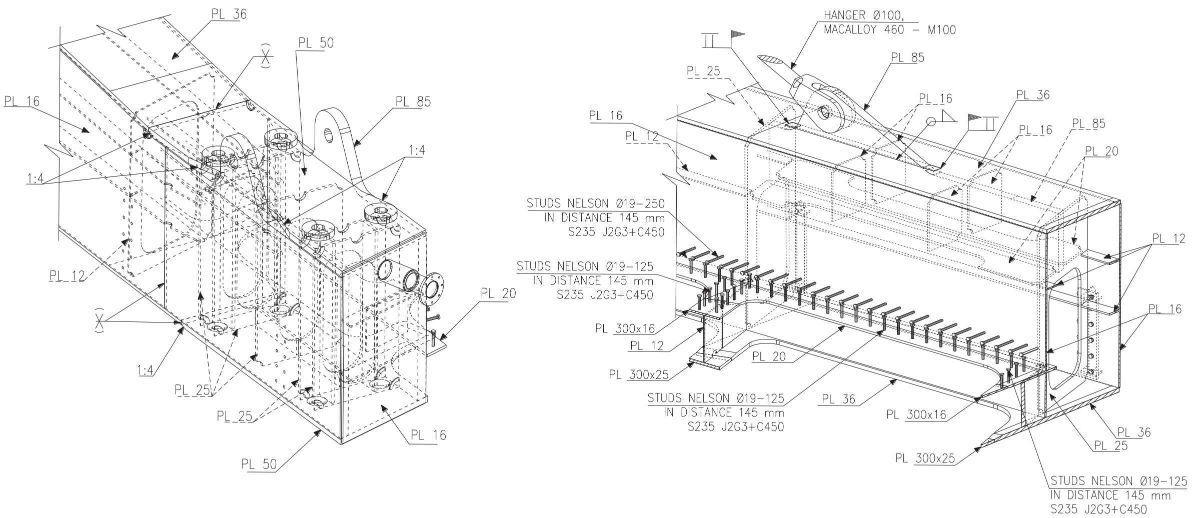

Fig. 5. (a) the end of main girder at the shorter span; (b) the section of main girder at the longer span with the starters of crossbeams

2.2. Crossbeams of the deck

The welded unsymmetrical I-shaped crossbeams were designed at the axial distance 3.0 m. In the grand plan, they follow 74° slant of the bridge to the river. They are fixed to the main girders by means of starters, created by the flanges with thickness 36 mm and the web with thickness 20 mm, Fig. 5. The bottom flange of crossbeams with dimension 25×300 mm is horizontal, while the top flange, made of plate 16x300 mm, follows a saddle lateral slope of the deck. Thus, the 12 mm thick crossbeam web is created from the plate with variable height - from 450 mm next to the starters to 568 mm in the middle of the bridge width.

2.3. Pylons and hangers

The pylon is 11.125 m tall. The width of the pylon cross-section is 900 mm, i.e. the same as the height of main girder. The height of the pylon cross-section varies linearly from 1500 mm in the axe of main girder to 700 mm at the top of the pylon. The flanges are 36 mm and webs are 16 mm thick. Thicknesses of both flanges as well as webs are constant through the height of pylon. Thus, from the side view it seems that the pylon is fluently rising up from the main girder. For pressed concreting, a temporary hole in upper end plate of the pylon was prepared, Fig. 6. After concrete fill the pylon and a main girder within the length of shorter span, the hole was closed by steel round covers.

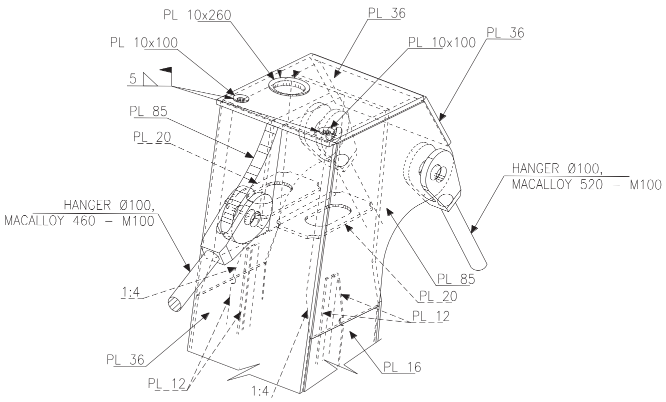

Fig. 6. The upper part of the pylon

As main hangers, three parallel rods Macalloy M100-460 are installed within the longer span of each main girder. They are anchored through the gusset plates 85 mm thick into the axis of the main girder and the pylon. The pair of balancing rods Macalloy M100-520 is placed in the shorter span into the webs of the main girders and pylon on the both sides of the bridge width. To avoid girder levelling above the bearing at the abutment No. 3 due to forces in balancing hangers, the prestressed rods are used. Firstly, the rods were concreted into the abutment. After erection of the superstructure, the rods were prestressed by special procedure designed for this purpose.

3. Reinforced concrete deck

Structure of the reinforced concrete bridge deck consists of precast reinforced concrete slabs 70 mm thick and monolithic reinforced concrete part with thickness of 130 mm. The precast concrete slabs created a sacrificial formwork for the monolithic part during construction. They were produced in a precast-concrete manufacture. The slabs are oriented in the longitudinal direction to be able to carry the weight of wet concrete and other loads associated with concrete casting. The reinforcement is designed and produced from reinforcing bars with diameters 16 and 20 mm. The spatial reinforcement made of steel bars of 7 mm diameter is used to transfer the shear forces. The apertures with the minimum diameter 80 mm are embedded in end slabs so that protecting tube with diameter 76 mm for lighting and for illumination could be thread through. For installation of drainage elements, the apertures with the minimum diameter 54 mm were also prepared. Reinforced concrete slabs are lying on the top flanges of the steel crossbeams. Their positions were fixed by welds to the interlock thorns, so that unintentional movement was prevented during the concreting process. Precast slabs are made of concrete specified in [5] as STN-EN 206-1-C45/55-XC3, XF2(SK)-Cl0.4-Dmax16-S3. The reinforcement of quality B 500 B was used. To prevent bleeding of the cement grout during concreting, the places of mutual joints between precast slabs, as well as the places of their bedding on crossbeams, were sealed with the mortar BASF Repafi.

The cast-in-situ part of the bridge deck has basic thickness 130 mm between the axes of drainage. The thickness varies from basic value to the maximum value 190 mm next to the main girder. It means, the slope of bridge deck is 2% from the centre to the drainage axis and 4% from the axis of drainage to the face of main girder. The reinforcement in the cast-in-situ part of the deck, additional to those in precast slab, is made of steel bars with diameter 20 mm. Connection of the cast-in-situ deck and the steel bridge structure is provided by NELSON studs with diameter 19 mm and lengths either 125 mm or 145 mm, respectively. Material of the studs is S235 J2G3+C450. The protection tubes, drainage elements and insulation had to be embedded with concreting works. To minimize concrete cracking, the concrete casting had to be made in parts, known as chess boarded working steps. The proposed method of concreting was discussed with a technologist. Material used for the monolithic part of bridge deck was the concrete of quality STN-EN 206-1-C30/37-XA1, XF1(SK)-Cl0.4-Dmax16-S3 and reinforcement was made of B 500 B, [2, 5].

4. Structure of sidewalks

The steel cantilevers create main bearing structure of the sidewalks. The cantilevers with variable cross-section, welded from steel plates, are fixed through the bolted connections into the main girders on the both sides of the bridge. The steel cantilevers of the sidewalks is supplemented by the secondary beams made of the hot rolled IPE220 sections, which are placed always in the middle between two main cantilevers and parallel to them. Longitudinal beams UPE220 were installed between the cantilevers to carry the secondary IPE beams. The timber beams of pavements are designed from the hard wood – black locust. The cross section of timber longitudinal beams was 120x150 mm. The beams are connected to the steel by galvanized studs Ø 10 mm with strength 8.8. Distance between axes of timber beams is 520 mm. The beams act as the double-span continuous beams supported at its end by the steel cantilevers. Intermediate support of the timber beams is created by the secondary steel girders IPE220. A foot-path layer of the pavements is also designed from hard wood – black locust. The cross-section of these timber planks is 120x65 mm. The elements are equipped by antiskid treatment. The strength class of timber D30 was considered in the static calculation.

5. Conclusions

The basic parameters of the new bridge structure in the town Nitra were described. Some untraditional solutions and details were applied during analysis and construction, as well. The bridge is already in service with trouble-free functionality. Besides, everybody who gets involved in this project certainly wants the bridge to be nice unit of surrounding urban area.

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